MicroNode I/O™

DeviceNet COMBO

User Manual

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Preface

About this manual

This manual is designed to serve as a guideline for the installation, setup, operation and basic maintenance of the MicroNode device. The information contained within this manual, including product specifications, is subject to change without notice. Please observe all safety precautions and use appropriate procedures when handling the MicroNode product and its related software.

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1 General Information

The MicroNode I/O™ product line provides high density, compact and economical I/O solutions for popular Fieldbus Networks. The MicroNode Combo provides 8 digital input/output points, 8 analog inputs, and 4 analog outputs on a DeviceNet™ network. The MicroNode package provides flexible side or foot mounting and easy access to I/O through a standard 37-pin D-Sub connector. All physical and object model features are ODVA Semi SIG compliant.

AS00124-01	MicroNode I/O, DeviceNet, Combo, sink, front
AS00125-01	MicroNode I/O, DeviceNet, Combo, sink, side
AS00127-01	MicroNode I/O, DeviceNet, Combo, source, front
AS00128-01	MicroNode I/O, DeviceNet, Combo, source, side

1.1 Conventions used in this User Manual

Warning **The WARNING sign denotes a hazard to personnel. It calls attention to a procedure, practice, condition, or the like, which, if not correctly performed or adhered to, could result in injury to personnel.**

Caution **The CAUTION sign higlights information that is important to the safe operation of the BlueBox, or to the integrity of your files. .**

Note **THE NOTE SIGN DENOTES IMPORTANT INFORMATION. IT CALLS ATTENTION TO A PROCEDURE, PRACTICE, CONDITION, OR THE LIKE, WHICH IS ESSENTIAL TO HIGHLIGHT.**

On screen buttons or menu items appear in bold and cursive.
Example: Click ***OK*** to save the settings.

Keyboard keys appear in brackets.
Example: [ENTER] and [CTRL]

Pages with additional information about a specific topic are cross-referenced within the text.
Example: (See page xxx)

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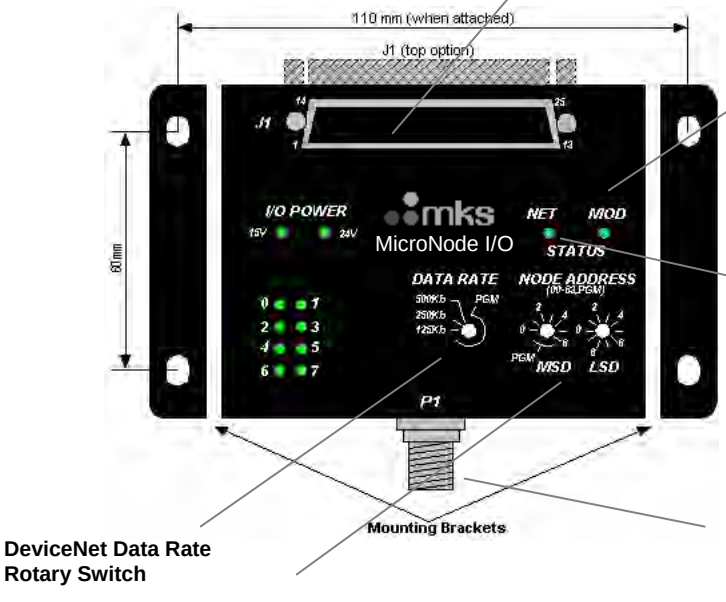
2 Installation and Setup

2.1 Shipping Box Contents

- MicroNode Product

2.2 MicroNode Hardware Description

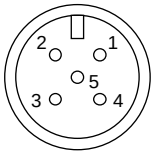


Module Status LED (MOD)

STATE	DESCRIPTION
OFF	No power
RED BLINK	Configuration error
RED	Unrecoverable error
GREEN BLINK	Not defined
GREEN	Normal operation

DeviceNet Status LED (NET)

STATE	DESCRIPTION
OFF	No power
RED BLINK	Configuration error
RED	Unrecoverable error
GREEN BLINK	Not allocated to a master
GREEN	Allocated to a master



DeviceNet Channel
(male 5-pin micro connector)

PIN	SIGNAL
1	SHIELD
2	V+
3	V-
4	CAN H
5	CAN L

2.3 Installation

Mount the MicroNode on a horizontal or vertical surface, in a suitable location or enclosure for your application. Provide sufficient clearance and airflow to maintain 0°C to 55°C ambient operating temperature range. Fasten the unit to the mounting surface using four screws (not provided) in the 4mm wide mounting holes.

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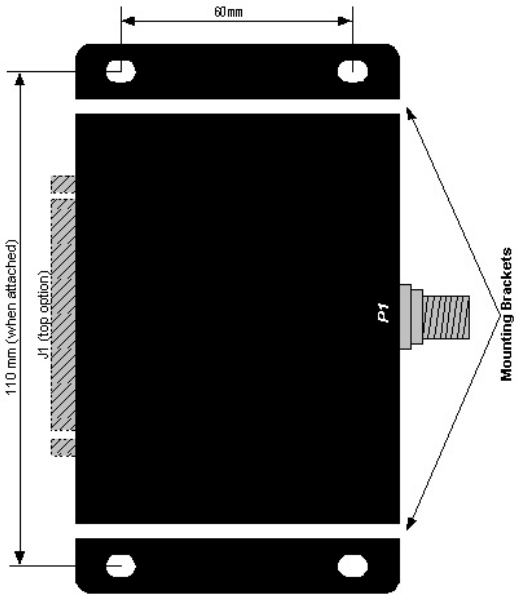


Height of 31mm,
not including D-Sub 37 connector

Note **ALL DIMENSIONS ARE METRIC**

2.4 Wiring

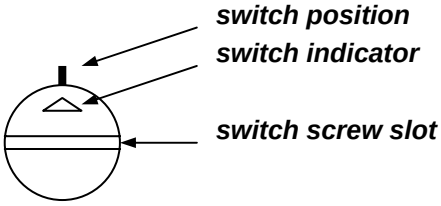
The MicroNode requires two connections – one to the DeviceNet network (male 5-pin micro connector) and one to the 37-pin D-SUB. DeviceNet™ and I/O cables are available from a variety of industrial sources. See table below for orderable I/O mating connectors.

Description	Distributor	Part Number
37-pin D-SUB Receptacle (solder cup)	Mouser	523-17D-C37S
37-pin D-SUB Metal Hood	Mouser	523-17-1727-2

Warning **Follow all applicable electrical codes in your area when mounting and wiring any electrical device.**

2.5 Rotary Switches

Set the MicroNode rotary switches to the desired settings. Use a small slotted screwdriver to rotate the switches. Align the indicator arrow to the desired setting, as shown below.



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Each rotary switch parameter has a **PGM** option. Setting a switch to PGM allows the parameter to be remotely set over DeviceNet. However, it must first be initialized. To initialize, set the switch to desired value and power up the unit. The new settings are saved in its memory. Power down and change switch to PGM mode.

2.6 Configuration

Rotary switches and software parameters are used to configure the MicroNode's *DeviceNet Interface* and I/O functions. The MicroNode is configured over its DeviceNet channel. Use your DeviceNet configuration application program and the MicroNode EDS file to set the software parameters over the DeviceNet channel.

2.6.1 Power Supply Wiring

All network circuits and the analog circuits are powered from DeviceNet power. Select your DeviceNet cables and power supply so that it can provide sufficient current for all networked devices at their peak operating power. For Digital I/O power, the 24-Volt power is supplied externally via the I/O Connector.

To power the Digital I/O from the DeviceNet power, you can remove the top cover, and add jumpers to JP4 and JP5, pins 1&2. This connection is fused at 2A for 24VDC supply to the I/O connector. Make sure that an additional power supply is not connected, as damage to the DeviceNet network may occur.

2.6.2 I/O Wiring

The MicroNode has a male 37-pin D-Sub for I/O. The pinout is shown in the following table.

Combo Model Connector			
Pin	**Signal**	**Pin**	**Signal**
1	24V GND	20	A GND
2	24V GND	21	A GND
3	24V GND	22	AO0
4	24V GND	23	AO1
5	24V GND	24	AO2
6	DIO7	25	AO3
7	DIO6	26	AI0
8	DIO5	27	AI1
9	DIO4	28	AI2
10	DIO3	29	AI3
11	DIO2	30	AI4
12	DIO1	31	AI5
13	DIO0	32	AI6
14	+24V IN	33	AI7
15	+24V IN	34	+15V REF
16	+24V IN	35	+15V REF
17	+24V IN	36	-15V REF
18	+24V IN	37	-15V REF
19	+24V IN		

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3 Quick-Start

This section describes the setup for a simple system using a DeviceNet™ master and a MicroNode module. Before beginning, a basic understanding of DeviceNet is recommended. Experience using explicit and poll transactions from the software provided with your DeviceNet master is essential. For more information on generating explicit and poll messages consult the DeviceNet master's software user's guide.

3.1 Hardware Setup

Setup a connection between a DeviceNet master and the MicroNode.

Required Hardware:

- DeviceNet cable
- DeviceNet master
- Power supply

3.2 Configuring the MicroNode

The major steps for configuring the MicroNode include setting up the DeviceNet I/O Objects.

Position the MicroNode switches as follows:

- MACID MSD to 0
- MACID LSD to 1
- DeviceNet data rate to 500K

Once all of the hardware is setup and powered, make sure that the master can allocate both poll and explicit connections to the MicroNode. Once allocated, both the NET and MOD LED will be solid green.

Warning **At this point, if the network and module LEDs on both the master and MicroNode are not solid green, do not proceed. Ensure the master baud rate matches the switch on the MicroNode, and that the MicroNode has a node address that is not used by another node on the network.**

Out of the box the MicroNode is pre-configured to control both digital and analog I/O. Refer to chapter 5 to create a custom I/O configuration.

3.3 Enabling the I/O

Reading Input Points

Set Explicit Message data as shown. Set Instance value for desired input point (1-16). Turn on an Input, and verify the LED has turned on. Read the input through the Explicit Message below.

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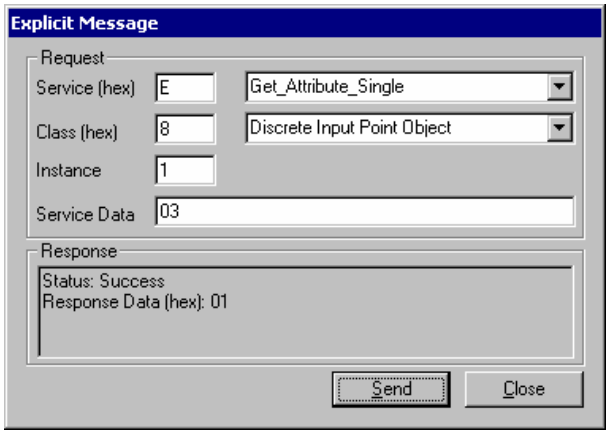
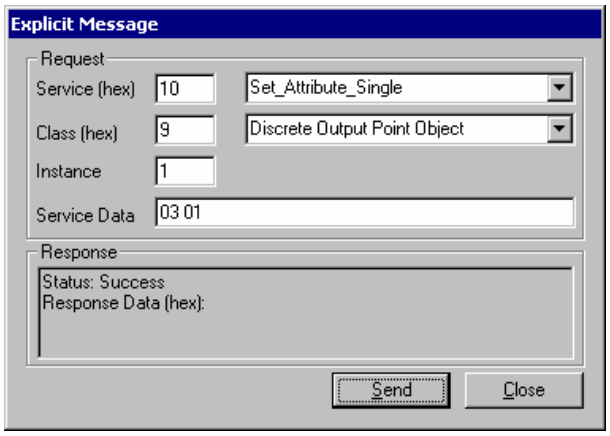


Setting Output Points

Set Explicit Message data as shown. Set Instance value for desired output point (1-16). To turn on the output point, set Service Data to "03 01" and observer the LED has turned on. To turn off a point, set Service Data to "03 00".



Note

The Instance for an I/O point is numbered 1 – 8, where as the I/O is labeled 0 – 7.

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4 Theory of Operation

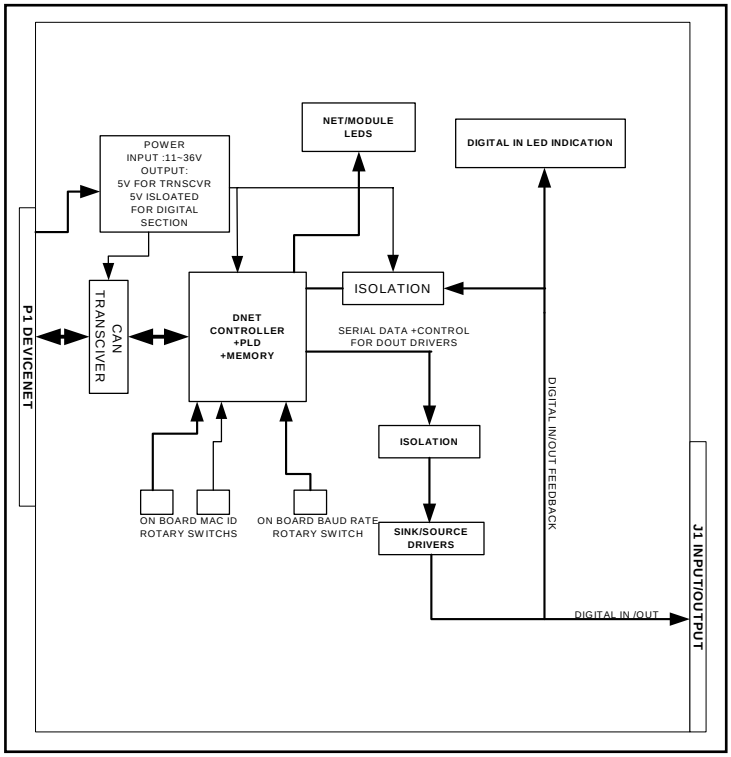
This chapter describes how the MicroNode operates. Working knowledge of DeviceNet is required before continuing. The Open DeviceNet Vendors Association (www.odva.com) is a good source for general DeviceNet information.

4.1 DeviceNet Interface

The DeviceNet Specification defines an Object Model that consists of Objects and Attributes. An Object is a predefined software process, and an Object Attribute is a data value used or created by that process. An Object can have multiple Instances, or the same process operating with different sets of Attributes or data values. For the purpose of this document, an Object Instance is an independent program or process, and its Attributes are configuration parameters and data values that are unique to that specific Object Instance.

The MicroNod has eleven different Object Classes, or types. Five are standard objects defined by the DeviceNet Specification (*Identity, Router, DeviceNet, Assembly, Connection*). Other specific objects defined for the MicroNode include (*Discrete Digital Input, Discrete Digital Output, Discrete Analog Input, Discrete Analog Output, Supervisory Object, User Defined Configuration Object)*.

The MicroNode operates as a DeviceNet slave. It supports Explicit Messages and Polled I/O Messages of the predefined master/slave connection set. The Explicit Unconnected Message Manager (UCMM) is not supported. The MicroNode will be a Group 2 Only Slave device. It will support Polled I/O and Explicit Messaging. The DeviceNet interface hardware complies with the DeviceNet Physical Layer specification.



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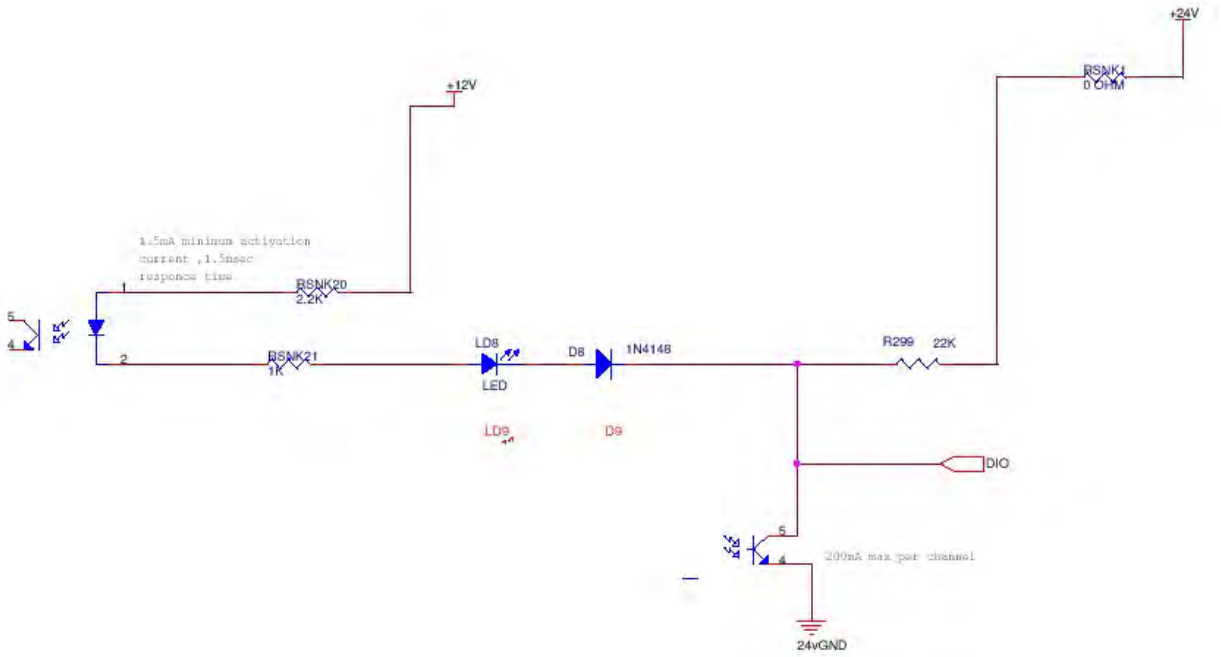
4.1.1 Digital I/O

The Digital I/O is optically coupled from the processor. The individual outputs will support up to 200 mA loads per channel. Based on package dissipation the maximum fully loaded output current is 100 mA (8 outputs) at 50 ^{o}C ambient. Each output is thermally protected for short circuit (500 mA typically) and includes under voltage protection. The output Fault State is accessible through software. External Schottky diodes are provided for output transient protection and each I/O point is protected with a self-resetting poly fuse rated for 200 mA. Outputs default to the OFF condition during power up and processor reset conditions.

The digital output read back signals (inputs) are active low, with current limiting resistors setting the short circuit current to 3 mA at 24 Vdc. Each input circuit includes an indicator LED in series with the detection opto-coupler. Both the detection opto-coupler and the indicator LED are protected with a shunt diode against reverse voltage breakdown.

The digital I/O circuitry is powered from an external +24-VDC power source unless jumpers are placed internally on JP4 and JP5. When the Jumpers are installed, the +24-VDC is supplied by the CAN Bus+ and Bus- pins. By default the +24-VDC must be supplied externally on the I/O connector.



Digital I/O Schematic

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4.1.2 Analog Inputs

The Analog inputs are coupled directly to the processor and are implemented using 12-bit A/D Converters. This device supports software settable ranges of 0V to 10V, and –5V to +5V.

All Analog circuitry is powered from an internal ±15 Vdc power source (1 Watt) derived from the 24 Volt DeviceNet power. The ±15-VDC power is protected with a self-resetting poly fuse rated at 100 mA.

4.1.3 Analog Outputs

The analog outputs are implemented using 12-bit D/A's with a –10V to +10V output range. The output drivers are capable of driving 2 KΩ (5 mA) output loads. Analog outputs default to 0 volts during power up and processor reset conditions. The analog output power is derived from the same ±15-VDC power used for the analog inputs.

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5 MicroNode Configuration

This chapter describes how to configure and operate the MicroNode. The MicroNode is configured by reading and writing attribute values over the DeviceNet interface. There are a variety of DeviceNet configuration tools available. Simple configuration tools use GET_ATTRIBUTE and SET_ATTRIBUTE explicit message commands to read and write attribute values, addressing each attribute by its *Object*, *Instance*, and *Attribute* numbers. More sophisticated configuration tools use EDS files to simplify attribute configuration.

5.1 Configure DeviceNet Interface

The DeviceNet Baud Rate and MAC ID Address are set using the rotary switches. Configure switches before powering the device. There is either a small triangular indicator or white indicator on the switch. Use a small screwdriver to align that indicator with the desired setting.

5.1.1 DeviceNet Baud Rate Switch

Valid settings are 125K, 250K, 500K, or PGM. When PGM is selected, the MicroNode uses the baud rate saved in its retentive memory. To save a valid baud rate in memory, set the switch to the desired baud rate and power up the MicroNode for a few seconds. Power down and set the switch to PGM. You may also write to the DeviceNet Object Baud Rate attribute.

POSITION	SETTING
0	125 Kbps
1	250 Kbps
2	500 Kbps

5.1.2 MAC ID Switches

The two MAC ID switches represent decimal numbers from 00 to 99. The LSB switch selects the *Ones* digit and the MSB switch selects the *Tens* digit. Valid MAC IDs are 00 to 63. Setting a MAC ID address greater than 63 forces the device to use the MAC ID saved in retentive memory. To save a valid MAC ID in memory, set the switches to the desired MAC ID and power up the MICRONODE for a few seconds. Power down and set the switches to value greater than 63. You may also write to the DeviceNet Object MAC ID attribute.

MSB	LSB	Address	MSB	LSB	Address
0	0 to 9	00 to 09	6	4 to 9	stored address
1	0 to 9	10 to 19	7	0 to 3	stored address
2	0 to 9	20 to 29	8	0 to 9	stored address
3	0 to 9	30 to 39	9	0 to 9	stored address
4	0 to 9	40 to 49			
5	0 to 9	50 to 59			
6	0 to 3	60 to 63			

5.2 Power Up

Connect the DeviceNet network cable and I/O cable to power up the MicroNode.

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5.2.1 DeviceNet Status LEDs

The MicroNode has two bi-color status LEDs (*NET* and *MOD*) that indicate operational status. During power-up, the LEDs cycle through a sequence of alternating red and green. After power-up, the *NET* LED should be flashing green (or solid green if allocated to a DeviceNet master) and the *MOD* LED should be solid green. If this does not occur, disconnect from DeviceNet and verify all the switch settings.

State	DeviceNet Status LED (*NET*)
Off	No power.
Flashing Red	Configuration error. Check DeviceNet switch settings.
Solid Red	Unrecoverable error.
Flashing Green	Device not allocated to a DeviceNet master.
Solid Green	Normal runtime, device allocated as a slave.

State	Module Status LED (*MOD*)
Off	No power.
Flashing Red	Configuration error. Check object attribute settings.
Solid Red	Unrecoverable error.
Flashing Green	Not defined.
Solid Green	Normal Operation.

5.3 Register EDS File

If using a DeviceNet configuration tool that supports Electronic Data Sheet (EDS) files, the latest EDS file versions can be downloaded from *www.mksinst.com*. Select the EDS file that matches the part number and firmware version. Follow the configuration tool instructions to register EDS file.

5.4 Polled I/O Configuration

A polled connection to the MicroNode Combo will be determined by the Configuration Object, Class Code 100. See chapter 6 for the default polled connection list.

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6 DeviceNet Object Model

The MicroNode operates as a slave on the DeviceNet network. The unit supports Explicit Messages and Polled I/O Messages of the predefined master/slave connection set. It does not support the Unconnected Message Manager (UCMM).

DeviceNet Message Types (Slave Receive)

As a group 2 slave device the Combo MicroNode supports the following received message types.

CAN IDENTIFIER	GROUP 2 Message Type
10xxxxxx100	Master Explicit Request Message
10xxxxxx101	Master I/O Poll Command Message
10xxxxxx110	Unconnected Explicit Request Message
10xxxxxx111	Duplicate MACID Check Message

xxxxxx = Node Address

DeviceNet Object Classes

The MicroNode device supports the following DeviceNet object classes.

CLASS CODE	OBJECT TYPE
01 (0x01)	Identity
02 (0x02)	Router
03 (0x03)	DeviceNet
04 (0x04)	Assembly
05 (0x05)	Connection
08 (0x08)	Discrete Input Point
09 (0x09)	Discrete Output Point
10 (0x0A)	Analog Input Point
11 (0x0B)	Analog Output Point
48 (0x30)	S-Device Supervisor
100 (0x64)	Configuration

6.1 Identity Object Class Code: 01 (0x01)

The Identity Object is required on all devices and provides identification of and general information about the device.

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Table 1. Class Attributes

Attribute	Access	Name	Type	Value
1	Get	Revision	UINT	1
2	Get	Max Instance	UINT	1
6	Get	Max Class Attribute ID	UINT	7
7	Get	Max Instance Attribute ID	UINT	8

Table 2. Instance 1 Attributes

Attribute	Access	Name	Type	Value
1	Get	Vendor ID	UINT	664 = “MKS – Tenta”
2	Get	Device Type	UINT	100 = Vendor Specific
3	Get	Product Code	UINT	124
4	Get	Revision	STRUCT of:	See Below
		Major Revision	USINT	
		Minor Revision	USINT	
5	Get	Status	WORD	See Below
6	Get	Serial Number	UDINT	See Below
7	Get	Product Name	SHORT STRING	“DNIO-0124”
8	Get	State	USINT	See Below

Table 3. Common Services

Service Code	Class	Instance	Service Name
05 (0x05)	No	Yes	Reset
14 (0x0E)	Yes	Yes	Get_Attribute_Single

Table 4. Reset Service

Reset Value	Description
0	Reset device. Simulates recycling of the CPU power.
1	Reset device to “out-of-box” configuration, then reset device.

6.1.1 Revision – Attribute 4

MKS/CIT maintains strict revision control. The major revision number will increment as functional enhancements are implemented. The minor revision will increment if minor changes are incorporated.

6.1.2 Status – Attribute 5

Bit (s):	Called:	Definition
0	Owned	TRUE indicates the device has an owner. Within the Master/Slave paradigm the setting of this bit means that the Predefined Master/Slave Connection Set has been allocated to a master.

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Bit (s):	Called:	Definition
1		Reserved, set to 0.
2	Configured	TRUE indicates the application of the device has been configured to do something different than the “out–of–box” default. This does not include configuration of the communications.
3		Reserved, set to 0.
4, 5, 6, 7		Vendor-specific
8	Minor Recoverable Fault	TRUE indicates the device detected a problem with itself, which is thought to be recoverable. The problem does not cause the device to go into one of the faulted states.
9	Minor Unrecoverable Fault	TRUE indicates the device detected a problem with itself, which is thought to be unrecoverable. The problem does not cause the device to go into one of the faulted states.
10	Major Recoverable Fault	TRUE indicates the device detected a problem with itself, which caused the device to go into the “Major Recoverable Fault” state.
11	Major Unrecoverable Fault	TRUE indicates the device detected a problem with itself, which caused the device to go into the “Major Unrecoverable Fault” state.
12, 13		Reserved, set to 0.
14, 15		Reserved, set to 0.

6.1.3 Serial Number – Attribute 6

The serial number is encoded in the product during the manufacturing cycle and is guaranteed to be unique across all product lines produced by MKS/CIT.

6.1.4 State – Attribute 8

The State reflects whether any errors have occurred and the severity. The following states are supported. The only exit from a Major Unrecoverable fault condition is power cycling the device.

State	Interpretation	Causes
0	Nonexistent	
1	Device Self Testing	
2	Standby	
3	Operational	
4	Major Recoverable fault	See S_Device_Supervisor
5	Major Unrecoverable fault	See S_Device_Supervisor

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6.2 Router Object Class Code: 02 (0x02)

The Message Router Object provides a messaging connection point through which a Client may address a service to any object class or instance residing in the physical device.

Table 5. Class Attributes

Attribute	Access	Name	Type	Value
1	Get	Revision	UINT	1
6	Get	Max Class Attribute ID	UINT	7
7	Get	Max Instance Attribute ID	UINT	2

Table 6. Instance 1 Attributes

Attribute	Access	Name	Type	Value
2	Get	Number Available	UINT	2

Table 7. Common Services

Service Code	Class	Instance	Service Name
14 (0x0E)	Yes	Yes	Get_Attribute_Single

6.2.1 Number Available – Attribute 2

The MicroNode supports 1 explicit and 1 polled I/O message connection.

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6.3 DeviceNet ObjectClass Code: 03 (0x03)

Table 8. Class Attributes

Attribute	Access	Name	Type	Value
1	Get	Revision	UINT	2

Table 9. Instance 1 Attributes

Attribute	Access	Name	Type	Value
1	Get/Set	MACID	USINT	See Below
2	Get/Set	Baud Rate	USINT	See Below
3	Get/Set	Bus Off Interrupt	BOOL	See Below
4	Get/Set	Bus Off Counter	USINT	See Below
5	Get	Allocation Information	STRUCT of	See Below
		Choice Byte	BYTE	
		Master Node Addr.	USINT	
6	Get	Mac Switch Changed	BOOL	0 = No 1 = Yes
7	Get	Baud Switch Changed	BOOL	0 = No 1 = Yes
8	Get	Current Mac Switch	USINT	Switch Value
9	Get	Current Baud Switch	USINT	Switch Value

Table 10. Common Services

Service Code	Class	Instance	Service Name
14 (0x0E)	Yes	Yes	Get_Attribute_Single
16 (0x10)	No	Yes	Set_Attribute_Single
75 (0x4B)	No	Yes	Allocate Master/Slave
76 (0x4C)	No	Yes	Release Master/Slave

6.3.1 MACID – Attribute 1

The MACID is set using two BCD rotary switches located on the front panel. Valid MACID addresses are 0 to 63 (0 to 3F Hex). Setting the switch address to a value greater than 63 will disable the switch and allow software setting of the MACID. If the switches are set to a value greater than 63, then the MAC ID attribute is settable. The software setting defaults to the last hardware setting. The switch is only read during power up.

6.3.2 Baud Rate – Attribute 2

Settable only if the Baud Rate switch is set to a value greater than 2. Value returned would be switch value if less than 3 or the last value set.

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Switch/Value	Speed
0	125 kbits
1	250 kbits
2	500 kbits
3	Software settable

6.3.3 Bus Off Interrupt – Attribute 3

Bus Off Interrupt (BOI) determines the action if a Bus Off state is encountered.

BOI Value	Action
0	Hold chip on OFF state (default)
1	Try to reset CAN controller.

6.3.4 Bus Off Counter – Attribute 4

Bus Off Counter will be forced to 0 whenever set, regardless of the data value provided.

6.3.5 Allocation Information – Attribute 5

Choice Byte

Bit	Description
7-2	Reserved. Always 0.
1	If set, polled I/O connection to be allocated.
0	If set, explicit message connection to be allocated.

6.4 Assembly Object Class Code: 04 (0x04)

The Assembly Objects bind attributes of multiple objects to allow data to or from each object to be sent or received over a single connection.

Table 11. Class Attributes

Attribute	Access	Name	Type	Value
1	Get	Revision	UINT	2
2	Get	Max Instance	UINT	101

Table 12. Instance 100 Attributes

Attribute	Access	Name	Type	Value
3	Get	Data	STRUCT of	
		Status	BYTE	See Configuration Object
		Digital Inputs	BYTE	See Configuration Object
		Pad	USINT	See Configuration Object

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Attribute	Access	Name	Type	Value
		Analog Inputs	INT[ ] or UINT[ ]	See Configuration Object

Table 13. Instance 101 Attributes

Attribute	Access	Name	Type	Value
3	Get	Data	STRUCT of	
		Digital Outputs	BYTE	See Configuration Object
		Pad	USINT	See Configuration Object
		Analog Outputs	INT[ ] or UINT[ ]	See Configuration Object

Table 14. Common Services

Service Code	Class	Instance	Service Name
14 (0x0E)	Yes	Yes	Get_Attribute_Single
16 (0x10)	No	Yes	Set_Attribute_Single

Data Type of AIO

The data type of the analog inputs can either be INT or UINT. See the Analog Input Point object for the current setting.

The data type of the analog outputs can either be INT or UINT. See the Analog Output Point object for the current setting.

Note **Assembly instance 100 is used to generate the poll response packet, and assembly instance 101 is used to consume the poll request packet. See section 6.10 for custom poll configuration.**

6.4.1 Default Assembly Object Instance 100 and 101 Structure

The table below shows the format of Assembly instance 100 and 101 with the “out-of-box” attributes values of the Configuration object. The poll produce size is 18 bytes and the consume size is 10 bytes by default.

Instance	Byte	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
100	0	DI 7	DI 6	DI 5	DI 4	DI 3	DI 2	DI 1	DI 0
	1	0x00							
	2	AI 0 – LSB							
	3	AI 0 – MSB							
	4	AI 1 – LSB							
	5	AI 1 – MSB							
	6	AI 2 – LSB							

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Instance	Byte	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
	7	AI 2 – MSB							
	8	AI 3 – LSB							
	9	AI 3 – MSB							
	10	AI 4 – LSB							
	11	AI 4 – MSB							
	12	AI 5 – LSB							
	13	AI 5 – MSB							
	14	AI 6 – LSB							
	15	AI 6 – MSB							
	16	AI 7 – LSB							
	17	AI 7 – MSB							
101	0	DO 7	DO 6	DO 5	DO 4	DO 3	DO 2	DO 1	DO 0
	1	0x00							
	2	AO 0 – LSB							
	3	AO 0 – MSB							
	4	AO 1 – LSB							
	5	AO 1 – MSB							
	6	AO 2 – LSB							
	7	AO 2 – MSB							
	8	AO 3 – LSB							
	9	AO 3 – MSB							

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Connection Object Class Code: 05 (0x05)

The Connection Objects manage the characteristics of each communication connection. As a Group II Only Slave device the unit supports one explicit message connection and one poll I/O message connection.

Table 15. Class Attributes

Attribute	Access	Name	Type	Value
1	Get	Revision	UINT	1

Table 16. Instance 1 Attributes (Explicit Connection)

Attribute	Access	Name	Type	Value
1	Get	State	USINT	See Below
2	Get	Instance Type	USINT	0 = Explicit Message
3	Get	Transport Class Trigger	USINT	0x83
4	Get	Produced Connection ID	UINT	See Below
5	Get	Consumed Connection ID	UINT	See Below
6	Get	Initial Comm. Char.	USINT	0x21
7	Get	Production Size	UINT	256
8	Get	Consumed Size	UINT	256
9	Get/Set	Expected Packet Rate	UINT	default 2500 msec
12	Get/Set	Watchdog Timeout Action	USINT	See Below
13	Get	Prod. Path Length	UINT	0
14	Get	Production Path		(null)
15	Get	Cons. Path Length	UINT	0
16	Get	Consumed Path		(null)

Table 17. Instance 2 Attributes (POLL connection)

Attribute	Access	Name	Type	Value
1	Get	State	USINT	See Below
2	Get	Instance Type	USINT	1 = I/O Message
3	Get	Transport Class Trigger	USINT	0x82
4	Get	Produced Connection ID	UINT	See Below
5	Get	Consumed Connection ID	UINT	See Below
6	Get	Initial Comm. Char.	USINT	0x01
7	Get	Production Size	UINT	See Below
8	Get	Consumed Size	UINT	See Below
9	Get/Set	Expected Packet Rate	UINT	0
12	Get/Set	Watchdog Timeout Action	USINT	See Below
13	Get	Prod. Path Length	UINT	6
14	Get	Production Path	STRUCT of	
		Log. Seg., Class	USINT	0x20
		Class Number	USINT	0x04
		Log.Seg., Instance	USINT	0x24

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		Instance Number	USINT	0x64
		Log.Seg., Attribute	USINT	0x30
		Attribute Number	USINT	0x03
15	Get	Cons. Path Length	UINT	6
16	Get	Consume Path	STRUCT of	
		Log. Seg., Class	USINT	0x20
		Class Number	USINT	0x04
		Log.Seg., Instance	USINT	0x24
		Instance Number	USINT	0x65
		Log.Seg., Attribute	USINT	0x30
		Attribute Number	USINT	0x03

Table 18. Common Services

Service Code	Class	Instance	Service Name
05 (0x05)	Yes	Yes	Reset
14 (0x0E)	Yes	Yes	Get_Attribute_Single
16 (0x10)	No	Yes	Set_Attribute_Single

6.4.2 State – Attribute 1

Connection State	Description
0	Non-Existent
1	Configuring
3	Established
4	Timed Out

6.4.3 Connection ID's – Attributes 4 and 5

Connection 1 Produced Connection ID: 10xxxxxx011
Connection 1 Consumed Connection ID: 10xxxxxx100

Connection 2 Produced Connection ID: 01111xxxxxx
Connection 2 Consumed Connection ID: 10xxxxxx101

Note **xxxxxx = Node Address.**

6.4.4 Production and Consumed Sizes – Attributes 7 and 8

The Production and Consumed sizes will change based on the Assembly instance are structured based on the Configuration Object. The Table below will define the maximum Production and Consumed sizes will their respective Assembly.

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Assembly	Production Size	Consumed Size
100	18	
101		10

6.4.5 Watch Dog Timeout Activity – Attribute 12

Watchdog Timeout Value	Description
0	Timeout (I/O Messaging default)
1	Auto Delete (Explicit Messaging default)
2	Auto Reset
3	Deferred Delete

6.5 Discrete Input Point Object Class Code: 08 (0x08)

The Discrete Input Point (DIP) Object models discrete inputs in a product. You can use this object in applications as simple as a toggle switch or as complex as a discrete I/O control module. There is a separate instance for each discrete input available on the device.

Table 19. Class Attributes

Attribute	Access	Name	Type	Value
1	Get	Revision	UINT	2
2	Get	Max Instance	UINT	8
6	Get	Max Class Attribute ID	UINT	7
7	Get	Max Instance Attribute ID	UINT	4

Table 20. Instance 1-8 Attributes

Attribute	Access	NV	Name	Type	Value
3	Get	V	Value	BOOL	0 = Off 1 = On
4	Get	V	Status	BOOL	0 = Okay 1 = Faulted

Table 21. Common Services

Service Code	Class	Instance	Service Name
14 (0x0E)	Yes	Yes	Get_Attribute_Single

6.5.1 Input State – Attribute 3

Attribute 3 provides the state of the specific digital input. A value of 0 indicates an OFF state and a value of 1 indicates an ON state. The Digital inputs provide feedback of the digital output states. If the corresponding output state is set to 0 these points may be used as inputs.

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6.5.2 Status – Attribute 4

If the MicroNode's I/O input power falls below 18Vdc, the discrete input point's value will be indeterminist and the status will report as faulted. This is the only cause for a faulted discrete input point.

6.6 Discrete Output Point Object Class Code: 09 (0x09)

The Discrete Output Point (DOP) Object models discrete outputs in a product. You can use this object in applications as simple as an actuator or as complex as a discrete I/O control module. There is a separate instance for each discrete output available on the device.

Table 22. Class Attributes

Attribute	Access	Name	Type	Value
1	Get	Revision	UINT	1
2	Get	Max Instance	UINT	8
6	Get	Max Class Attribute ID	UINT	7
7	Get	Max Instance Attribute ID	UINT	8

Table 23. Instance 1-8 Attributes

Attribute	Access	NV	Name	Type	Value
3	Get	V	Value	BOOL	**0 = Off** 1 = On
4	Get	V	Status	BOOL	0 = Okay 1 = Faulted
5	Get/Set	NV	Fault Action	BOOL	0 = Fault Value attribute 1 = hold last value
6	Get/Set	NV	Fault Value	BOOL	0 = Off 1 = On
7	Get/Set	NV	Idle Action	BOOL	0 = Idle Value attribute 1 = hold last value
8	Get/Set	NV	Idle Value	BOOL	0 = Off 1 = On

Table 24. Common Services

Service Code	Class	Instance	Service Name
14 (0x0E)	Yes	Yes	Get_Attribute_Single
16 (0x10)	No	Yes	Set_Attribute_Single

6.6.1 Output State – Attribute 3

The digital outputs are sinking or sourcing depending on the part number ordered. Setting a DOP state to 1 forces the corresponding output pin low (sinking) or high (sourcing). The state of each DOP may be read back using the DOP state or the corresponding DIP state. The DIP state reflects the state of the I/O pin. If an I/O point is to be used as an input the corresponding DOP state must be set to 0 (off).

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6.6.2 Status – Attribute 4

If the Combo MicroNode's I/O input power falls below 18Vdc, the discrete output point's value will be indeterminist and the status will report as faulted. This is the only cause for a faulted discrete output point.

6.7 Analog Input Point Object Class Code: 10 (0x0A)

Table 25. Class Attributes

Attribute	Access	Name	Type	Value
1	Get	Revision	UINT	2
2	Get	Max Instance	UINT	8
6	Get	Max Class Attribute ID	UINT	7
7	Get	Max Instance Attribute ID	UINT	8

Table 26. Instance 1-8 Attributes

Attribute	Access	NV	Name	Type	Value
3	Get	V	Value	(See Value Data Type)	See Below
4	Get	V	Status	BOOL	0 = Okay 1 = Faulted
7	Get/Set	NV	Input Range	USINT	2 = 0V to 10V 6 = -5V to +5V
8	Get/Set	NV	Value Data Type	USINT	0 = INT 6 = UINT

Table 27. Common Services

Service Code	Class	Instance	Service Name
14 (0x0E)	Yes	Yes	Get_Attribute_Single
16 (0x10)	No	Yes	Set_Attribute_Single

6.7.1 Value – Attribute 3

The following table is a list of values based the Input Range attribute, Value Data Type attribute, and the resolution of the ADC being 12-bits

Data Type	INT	UINT	INT	UINT
Range	**0V to 10V**	0V to 10V	**-5V to +5V**	-5V to +5V
-10V	0x0000	0x0000	0xF800	0x0000
-5V	0x0000	0x0000	0xF800	0x0000
0V	0x0000	0x0000	0x0000	0x0800
5V	0x0800	0x0800	0x07FF	0x0FFF
10V	0x0FFF	0x0FFF	0x07FF	0x0FFF

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6.7.2 Status – Attribute 4

If the Combo MicroNode's ±15V input power falls below tolerance, the analog input point's value will be indeterminist and the status will report as faulted. Also, if there is a bad read on the ADC, that channel will be faulted as well.

6.8 Analog Output Point Object Class Code: 11 (0x0B)

Table 28. Class Attributes

Attribute	Access	Name	Type	Value
1	Get	Revision	UINT	1
2	Get	Max Instance	UINT	4
6	Get	Max Class Attribute ID	UINT	7
7	Get	Max Instance Attribute ID	UINT	12

Table 29. Instance 1-4Attributes

Attribute	Access	NV	Name	Type	Value
3	Get/Set	V	Value	**(See Value Data Type)**	See Below
4	Get	V	Status	BOOL	0 = Okay 1 = Faulted
7	Get	NV	Output Range	USINT	3 = -10V to +10V
8	Get/Set	NV	Value Data Type	USINT	0 = INT 6 = UINT
9	Get/Set	NV	Fault State	USINT	0 = hold last state 1 = low limit 2 = high limit 3 = Fault Value
10	Get/Set	NV	Idle State	USINT	0 = hold last state 1 = low limit 2 = high limit 3 = Fault Value
11	Get/Set	NV	Fault Value	(See Value Data Type)	See Value
12	Get/Set	NV	Idle Value	(See Value Data Type)	See Value

Table 30. Common Services

Service Code	Class	Instance	Service Name
14 (0x0E)	Yes	Yes	Get_Attribute_Single
16 (0x10)	No	Yes	Set_Attribute_Single

6.8.1 Value, Fault Value, & Idle Value – Attributes 3, 11, &12

The following table is a list of values based the Value Data Type attribute and the resolution of the DAC being 12-bits.

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Data Type	INT	UINT
-10V	0xF800	0x0000
-5V	0xFC00	0x0400
0V	0x0000	0x0800
5V	0x0400	0x0C00
10V	0x07FF	0x0FFF

6.8.2 Status – Attribute 4

If the Combo MicroNode's ±15V input power falls below tolerance, the analog output point's value will be indeterministic and the status will report as faulted. This is the only cause for a faulted analog output point.

6.8.3 Fault & Idle States – Attributes 9 & 10

Care should be taken when setting this attribute. Depending on what the Value Data Type attribute is set to, will determine the value of the analog output when in the faulted stated.

Fault/Idle State	INT	UINT
Low limit	0x0000 = 0V	**0x0000 = -10V**
High limit	0x07FF = 10V	0x0FFF = 10V

6.9 S-Device Supervisor Object Class Code: 48 (0x30)

Table 31. Class Attributes

Attribute	Access	Name	Type	Value
1	Get	Revision	UINT	1
2	Get	Max Instance	UINT	1
6	Get	Max Class Attribute ID	UINT	7
7	Get	Max Instance Attribute ID	UINT	100

Table 32. Instance 1 Attributes

Attribute	Access	NV	Name	Type	Value
3	Get	NV	Device Type	SHORT STRING	"COMBO"
4	Get	NV	SEMI Standard Revision Level	SHORT STRING	"E54-0997"
5	Get	NV	Manufacturer's Name	SHORT STRING	"MKS Instruments"
6	Get	NV	Manufacturer's Model Number	SHORT STRING	"DNIO-0124"
7	Get	NV	Software Revision Level	SHORT STRING	See Below
8	Get	NV	Hardware Revision Level	SHORT STRING	See Below
9	Get	NV	Manufacturer's Serial Number	SHORT STRING	See Below

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Attribute	Access	NV	Name	Type	Value
11	Get	V	Device Status	USINT	See Below
12	Get	V	Exception Status	BYTE	See Below
13	Get	V	Exception Detail Alarm	STRUCT of	
			Common Exception Detail	STRUCT of	
			Size	USINT	2
			Detail	ARRAY of	
			Detail[0]	BYTE	See Below
			Detail[1]	BYTE	See Below
			Device Exception Detail	STRUCT of	
			Size	USINT	4
			Detail	ARRAY of	
			Detail[0]	BYTE	See Below
			Detail[1]	BYTE	See Below
			Detail[2]	BYTE	See Below
			Detail[3]	BYTE	See Below
			Manufacturer Exception Detail	STRUCT of	
			Size	USINT	1
			Detail	ARRAY of	
			Detail[0]	BYTE	See Below
14	Get	V	Exception Detail Warning	STRUCT of	
			Common Exception Detail	STRUCT of	
			Size	USINT	2
			Detail	ARRAY of	
			Detail[0]	BYTE	See Below
			Detail[1]	BYTE	See Below
			Device Exception Detail	STRUCT of	
			Size	USINT	4
			Detail	ARRAY of	
			Detail[0]	BYTE	See Below
			Detail[1]	BYTE	See Below
			Detail[2]	BYTE	See Below
			Detail[3]	BYTE	See Below
			Manufacturer Exception Detail	STRUCT of	

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Attribute	Access	NV	Name	Type	Value
			Size	USINT	1
			Detail	ARRAY of	
			Detail[0]	BYTE	See Below
15	Get/Set	NV	Alarm Enable	BOOL	0=Disable, 1=Enable
16	Get/Set	NV	Warning Enable	BOOL	0=Disable, 1=Enable
100	Get	V	Mode	USINT	0 = User 2 = Factory

Table 33. Common Services

Service Code	Class	Instance	Service Name
05 (0x05)	No	Yes	Reset
06 (0x06)	No	Yes	Start
07 (0x07)	No	Yes	Stop
14 (0x0E)	Yes	Yes	Get_Attribute_Single
16 (0x10)	No	Yes	Set_Attribute_Single

Table 34. Object-Specific Services

Service Code	Class	Instance	Service Name
75 (0x4B)	No	Yes	Abort
76 (0x4C)	No	Yes	Recover
78 (0x4E)	No	Yes	Perform_Diagnostics

Parameter	Form	Description
TestID	USINT	Type of diagnostic test to be performed

Test ID Parameter	Type of diagnostics to be performed
0	Standard

Table 35. Manufacturer-Specific Services

Service Code	Class	INSTANCE	Service Name
50 (0x32)	No	Yes	Change Mode
51 (0x33)	No	Yes	Jump to boot loader.

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6.9.1 Change Mode Request

Parameter	Form	Description
Password	UINT	0x0000 = User 0x**** = Factory

6.9.2 Jump To Boot Loader Request

Parameter	Form	Description
NULL	N/A	This service is only accessible in Factory Mode. It allows the device to jump to the CAN boot loader in order to download new firmware to the device.

6.9.3 Software Revision Level – Attribute 7

The Software Revision will be a text string of the Major and Minor revision information of the Identity object. It will have the format X.YYY, where X is the major revision and YYY is the Minor revision. The revision code will match that provided by the Identity object.

6.9.4 Hardware Revision Level – Attribute 8

The Hardware Revision will be a text string reflecting the current revision of the hardware. It will have the format X.YYY, where X is the major revision and YYY is the Minor revision.

6.9.5 Device Status – Attribute 11

Value	Description
1	Self Testing
2	Idle
3	Self-Test Exception
4	Executing
5	Abort
6	Critical Fault

6.9.6 Exception Status – Attribute 12

Bit	Function
0	ALARM/ device-common
1	ALARM/ device-specific
2	ALARM/ manufacturer-specific
3	Reserved – set to 0
4	WARNING/ device-common
5	WARNING/ device-specific
6	WARNING/ manufacturer-specific

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Bit	Function
7	1 == Expanded Method

6.9.7 Common Exception Detail – Attribute 13 and 14

Bit	Common Exception Detail[0]	Bit	Common Exception Detail[1]
0	Internal diagnostic exception	0	0
1	Microprocessor exception	1	0
2	EPROM exception	2	Power supply output voltage
3	EEPROM exception	3	Power supply input voltage
4	RAM exception	4	0
5	0 - Reserved by DeviceNet	5	Notify manufacturer
6	Internal real-time exception	6	Reset exception
7	0 - Reserved by DeviceNet	7	0 = Reserved by DeviceNet

6.9.8 Device Exception Detail – Attributes 13 and 14

The value in each field comes from the respective object's status attribute.

Byte	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
0	DI 7	DI 6	DI 5	DI 4	DI 3	DI 2	DI 1	DI 0
1	DO 7	DO 6	DO 5	DO 4	DO 3	DO 2	DO 1	DO 0
2	AI 7	AI 6	AI 5	AI 4	AI 3	AI 2	AI 1	AI 0
3	0	0	0	0	AO 3	AO 2	AO 1	AO 0

6.9.9 Manufacturer Exception Detail – Attributes 13 and 14

Bit	Manufacturer Exception Detail
0	I/O +24V Fault
1	+/- 15V Fault
2	0
3	0
4	0
5	DO over current protection.
6	Bad read on ADC.
7	CAN Overrun*

* Warning Exception only.

6.10 Configuration Object Class Code: 100 (0x64)

Table 36. Class Attributes

Attribute	Access	Name	Type	Value
1	Get	Revision	UINT	1

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2	Get	Max Instance	UINT	1
6	Get	Max Class Attribute ID	UINT	7
7	Get	Max Instance Attribute ID	UINT	104

Table 37. Instance 1 Attributes

Attr	Access	NV	Name	Type	Value
100	Get/Set [1]	NV	Mode	BYTE	See Below
101	Get/Set [1]	NV	Num Digital Input	USINT	See Below
102	Get/Set [1]	NV	Num Digital Output	USINT	See Below
103	Get/Set [1]	NV	Num Analog Input	USINT	See Below
104	Get/Set [1]	NV	Num Analog Output	USINT	See Below

Table 38. Common Services

Service Code	Class	Instance	Service Name
05 (0x05)	No	Yes [2]	Reset
14 (0x0E)	Yes	Yes	Get_Attribute_Single
16 (0x10)	No	Yes	Set_Attribute_Single

Note **1: This attribute is only settable when the poll connection is in the configuring state.**

Note **2: This service is only valid when the poll connection is in the configuring state.**

6.10.1 Reset Service

If a reset service is sent, then the attribute values will return to the “out-of-box” configuration.

6.10.2 Mode – Attribute 100

The Mode byte determines the format of Assembly instances 100 and 101 and the overall operation of the unit during the I/O scanning function. The mode byte consists of 2 bits with the following interpretation.

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Include S-DSUP	Reserved	Reserved	Reserved	Reserved	Reserved	Reserved	**No Even Byte**

Note **Reserved bits cannot be set, and are read back as 0.**

If the Include S-DSUP bit is set, then the first byte in Assembly instance 100 will be the Exception Status byte in the S-Device Supervisor Object

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If the No Even Byte bit is set, then there will not be a padding bytes inserted in Assembly instance 100 or expected in Assembly instance 101. If the bit is cleared, then Assembly instance 100 and 101 will be adjusted to ensure that the Analog I/O data starts on an even byte boundary. Padding bytes will be eliminated from the Assembly instance 100 and 101 if the Num Analog Input and/or Num Analog Output are set to zero, respectively.

6.10.3 Num Digital Input – Attribute 101

The Num Digital Input attribute determines the number of discrete input points to be used in Assembly instance 100. The maximum number is 8. The number of bytes included in Assembly instance 100 is calculated as follows:

Number of digital input bytes = ((Num Digital Input) + 7) / 8);

6.10.4 Num Digital Output – Attribute 102

The Num Digital Output attribute determines the number of discrete output points to be used in Assembly instance 101. The maximum number is 8. The number of bytes included in Assembly instance 101 is calculated as follows:

Number of digital output bytes = ((Num Digital Output) + 7) / 8);

6.10.5 Num Analog Input – Attribute 103

The Num Analog Input attribute determines the number of analog input points to be used in Assembly instance 100. The maximum number is 8. The number of bytes included in Assembly instance 100 is calculated as follows:

Number of analog input bytes = (Num Analog Input * 2);

6.10.6 Num Analog Output – Attribute 104

The Num Analog Output attribute determines the number of analog output points to be used in Assembly instance 101. The maximum number is 4. The number of bytes included in Assembly instance 101 is calculated as follows:

Number of analog output bytes = (Num Analog Output * 2);

6.10.7 Default Values

The “out-of-box” configuration is described in the table below.

Attribute	Value	Description
100 – Mode	0x00	S-DSUP Exception Status byte not included in Assembly instance 100. There are padding bytes inserted into the Assembly instances to insure that Analog I/O data is on even byte boundaries.
101 – Num Digital Input	8	All 8 digital inputs will be used in Assembly instance 100.
102 – Num Digital Output	8	All 8 digital outputs will be used in Assembly instance 101.

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Attribute	Value	Description
103 – Num Analog Inputs	8	All 8 analog inputs will be used in Assembly instance 100.
103 – Num Analog Outputs	4	All 4 analog outputs will be used in Assembly instance 101.

6.10.8 Custom Assembly Instance 100 and 101 Structure

The format of Assembly instances 100 and 101 are determined by the attributes values in the Configuration object. Below is a table that shows one possibility other than the default outlined in section 6.4.

Mode = 0x80.
Num Digital In = 4.
Num Digital Out = 8.
Num Analog In = 8.
Num Analog Out = 2.

Instance	Byte	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
100	0	Exception Status – See S-Device Supervisor Object							
	1	0	0	0	0	DI 3	DI 2	DI 1	DI 0
	2	AI 0 – LSB							
	3	AI 0 – MSB							
	4	AI 1 – LSB							
	5	AI 1 – MSB							
	6	AI 2 – LSB							
	7	AI 2 – MSB							
	8	AI 3 – LSB							
	9	AI 3 – MSB							
	10	AI 4 – LSB							
	11	AI 4 – MSB							
	12	AI 5 – LSB							
	13	AI 5 – MSB							
	14	AI 6 – LSB							
	15	AI 6 – MSB							
	16	AI 7 – LSB							
	17	AI 7 – MSB							
101	0	DO 7	DO 6	DO 5	DO 4	DO 3	DO 2	DO 1	DO 0
	1	Padding Byte							
	2	AO 0 – LSB							
	3	AO 0 – MSB							
	4	AO 1 – LSB							
	5	AO 1 – MSB							

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7 Appendix A - Specifications

Physical Specifications

Criteria	Specifications
Dimensions	80mm (3.1496”) Height X 120mm (4.7244”) Width X 31mm (1.22”) Depth
I/O Connector	37-pin male D-sub
DeviceNet™ Connector	5-pin male microfast
Weight	200 g (0.44 lb)

Environmental Specifications

Criteria	Specifications
Operating Temperature	0 to +55°C
Storage	-40 to +85 °C
Humidity	5 to 95% non-condensing

Functional Specifications

Criteria	Specifications
BUS Interface	DeviceNet™
Front Panel Indicators	8 I/O points, Network Status, Module Status
Rotary Switches	MAC ID and Baud Rate

Power Specifications

Criteria	Specifications
Input	Powered from DeviceNet™ +24VDC@120 mA min
Isolation	DC/DC Isolation

Input/Output Specifications

Criteria	Specifications
Number of Digital I/O	8 points (input or output)
Digital Input	
Current sinking	Active Low- 1.5 mA min, 1.5 ms filtering
Current sourcing	Active High-1.5 mA min, 1.5 ms filtering
Digital Output	
Current sinking	Active low, 200 mA max / channel
Current sourcing	Active high, 200 mA max / channel
Current max	800 mA for DIO 0-7,
Analog Input	8 single-ended points 12 bit Software selectable range (0-10V), (–5 to +5V)
Analog Output	4 single -ended points 12 bit Range (–10 to +10V) 5mA / channel into a 2 KΩ load

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8 Warranty

MKS Instruments, Inc. (**MKS**) warrants that for one year from the date of shipment the equipment described above (the "equipment") manufactured by **MKS** shall be free from defects in materials and workmanship and will correctly perform all date-related operations, including without limitation accepting data entry, sequencing, sorting, comparing, and reporting, regardless of the date the operation is performed or the date involved in the operation, provided that, if the equipment exchanges data or is otherwise used with equipment, software, or other products of others, such products of others themselves correctly perform all date-related operations and store and transmit dates and date-related data in a format compatible with **MKS** equipment. THIS WARRANTY IS **MKS'** SOLE WARRANTY CONCERNING DATE-RELATED OPERATIONS.

For the period commencing with the date of shipment of this equipment and ending one year later, **MKS** will, at its option, either repair or replace any part which is defective in materials or workmanship or with respect to the date-related operations warranty without charge to the purchaser. The foregoing shall constitute the exclusive and sole remedy of the purchaser for any breach by **MKS** of this warranty.

The purchaser, before returning any equipment covered by this warranty, which is asserted to be defective by the purchaser, shall make specific written arrangements with respect to the responsibility for shipping the equipment and handling any other incidental charges with the **MKS** sales representative or distributor from which the equipment was purchased or, in the case of a direct purchase from **MKS**, with the **MKS-CIT** home office in San Jose, CA

This warranty does not apply to any equipment, which has not been installed and used in accordance with the specifications recommended by **MKS** for the proper and normal use of the equipment. **MKS** shall not be liable under any circumstances for indirect, special, consequential, or incidental damages in connection with, or arising out of, the sale, performance, or use of the equipment covered by this warranty.

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